Claims

[c1]

What is claimed is:

1. A method for wireless communications comprising:

providing a multicarrier direct-sequence code-division multiple-access (MS-DS/CDMA) communications system;

generating a code tree of two-dimensional orthogonal variable spreading factor (2D-OVSF) codes, wherein each node of the code tree has a corresponding matrix;

selecting an M × N matrix from a node of the code tree, where M relates to the number of available frequency carriers in the MS-DS/CDMA system, N relates to a spreading factor, $M=2^k$, $N=2^{k+\alpha}$, k is greater than zero, and α is greater than or equal to zero; and

assigning the M × N matrix to a MS-DS/CDMA-enabled device of the MS-DS/CDMA system to serve as a signature sequence of the device;

wherein generating the code tree comprises:

providing a first set of orthogonal 2 × 2 matrices $\{A^{(1)}(2 \times 2), A^{(2)}(2 \times 2)\}$;

providing a second set of orthogonal 2 × 2 matrices $\{B^{(1)}(2 \times 2), B^{(2)}(2 \times 2)\}$;

utilizing the first set of 2 × 2 matrices to generate a pair of progenitor nodes in the code tree that respectively represent matrices $A^{(1)}_{(2\times 2^{\alpha})}$ and $A^{(2)}_{(2\times 2^{\alpha})}$ by iterating the relationship:

$$A^{(1)}_{(2\times 2^{i+1})} = [A^{(1)}_{(2\times 2^{i})} \quad A^{(2)}_{(2\times 2^{i})}],$$
$$A^{(2)}_{(2\times 2^{i+1})} = [A^{(1)}_{(2\times 2^{i})} \quad -A^{(2)}_{(2\times 2^{i})}];\ \text{and}$$

utilizing the matrices $A^{(1)}_{(2\times 2^{\alpha})}$ and $A^{(2)}_{(2\times 2^{\alpha})}$ to generate a child node of one of the progenitor nodes, the child node having the M × N matrix, by iterating the relationship:

$$A^{(i-1)}_{(O\times P)} = [B^{(1)}_{(2\times 2)} \otimes A^{(i/2)}_{(O/2 \times P/2)}],$$
$$A^{(i)}_{(O\times P)} = [B^{(2)}_{(2\times 2)} \otimes A^{(i/2)}_{(O/2 \times P/2)}];$$

wherein ⊗ is a Kronecker product.

2. The method of claim 1 wherein children nodes of the code tree correspond to data transmission rates that are slower than those of parent nodes, thereby enabling multirate transmissions by utilizing orthogonal matrices in the code tree.

3. The method of claim 1 wherein children nodes of the progenitor nodes are in

the form of a binary tree.

4. The method of claim 1 wherein α is greater than zero.

5. The method of claim 1 wherein the first set of orthogonal 2×2 matrices is identical to the second set of orthogonal 2×2 matrices.

6. The method of claim 1 wherein any two matrices at an identical layer in the code tree are orthogonal to each other, and any two matrices at different layers in the code tree are orthogonal if and only if one of the matrices is not the parent code of the other matrix.

7. A wireless communications device comprising:

a multicarrier direct-sequence code-division multiple-access (MS-DS/CDMA) module for providing MC-DS/CDMA functionality to the wireless device according to a signature sequence; and

an $M \times N$ matrix generator for generating a two-dimensional orthogonal variable spreading factor (2D-OVSF) code to serve as the signature sequence, where M relates to the number of available frequency carriers available to the wireless device, N relates to a spreading factor, $M=2^{k}$, $N=2^{k+\alpha}$, k is greater than zero, and α is greater than or equal to zero, the $M \times N$ matrix generator providing:

a first set of orthogonal 2×2 matrices $\{A^{(1)}(2 \times 2), A^{(2)}(2 \times 2)\}$; and

a second set of orthogonal 2×2 matrices $\{B^{(1)}(2 \times 2), B^{(2)}(2 \times 2)\}$

the $M \times N$ matrix generator performing the following steps to generate the signature sequence:

utilizing the first and second 2×2 matrices to generate a progenitor matrix $A^{(1)}(2 \times 2^{\alpha})$ or $A^{(2)}(2 \times 2^{\alpha})$ by iterating the relationship:

$$A(1)_{(2 \times 2^{1+\beta})} = [A(1)_{(2 \times 2^{\beta})} \quad A(2)_{(2 \times 2^{\beta})}],$$

$$A(2)_{(2 \times 2^{1+\beta})} = [A(1)_{(2 \times 2^{\beta})} \quad -A(2)_{(2 \times 2^{\beta})}].$$

utilizing the matrix $A^{(1)}(2 \times 2^{\alpha})$ or $A^{(2)}(2 \times 2^{\alpha})$ to generate an $M \times N$ matrix by iterating the relationship:

$$A^{(i-1)}_{(O \times P)} = [B^{(1)}_{(2 \times 2)} \otimes A^{(i/2)}_{(O/2 \times P/2)}],$$

$$A^{(i)}_{(O \times P)} = [B^{(2)}_{(2 \times 2)} \otimes A^{(i/2)}_{(O/2 \times P/2)}];$$

wherein $\otimes$ is a Kronecker product.

8. The wireless device of claim 7 wherein the $M \times N$ matrix generator comprises a central processing unit (CPU) and memory, the memory storing the first set of orthogonal 2×2 matrices $\{A^{(1)}(2 \times 2), A^{(2)}(2 \times 2)\}$,the second set of

orthogonal 2 × 2 matrices{ $B^{(1)}$ (2 × 2), $B^{(2)}$ (2 × 2)},and program code executable by the CPU to perform the steps to generate the signature sequence.

9. The wireless device of claim 7 wherein α is greater than zero. 10. The wireless device of claim 7 wherein the first set of orthogonal 2 × 2 matrices is identical to the second set of orthogonal 2 × 2 matrices.

10. The wireless device of claim 7 wherein the first set of orthogonal 2 × 2 matrices is identical to the second set of orthogonal 2 × 2 matrices.

11. A wireless communications device comprising:

a multicarrier direct-sequence code-division multiple-access (MS-DS/CDMA) module for providing MC-DS/CDMA functionality to the wireless device according to a signature sequence; and

a memory for storing a code tree of two-dimensional orthogonal variable spreading factor (2D-OVSF) codes that are capable of serving as the signature sequence, the 2D-OVSF codes each expressible as an M × N matrix $A^{(i)}$ (M × N) in which M relates to the number of available frequency carriers available to the wireless device, N relates to a spreading factor, $M=2^k$, $N=2^{k+\alpha}$,k is greater than zero, i ranges from one to M, and α is greater than or equal to zero, the 2D-OVSF codes of the code tree being interrelated by:

$$A^{(1)}_{(2\times 2^{1+\alpha})} = [A^{(1)}_{(2\times 2^{\alpha})} \; A^{(2)}_{(2\times 2^{\alpha})}],$$
$$A^{(2)}_{(2\times 2^{1+\alpha})} = [A^{(1)}_{(2\times 2^{\alpha})} \; -A^{(2)}_{(2\times 2^{\alpha})}],$$
$$A^{(2i-1)}_{(M\times N)} = [B^{(1)}_{(2\times 2)} \otimes A^{(i/2)}_{(M/2\times N/2)}], \text{ and}$$
$$A^{(2i)}_{(M\times N)} = [B^{(2)}_{(2\times 2)} \otimes A^{(i/2)}_{(M/2\times N/2)}],$$

wherein ⊗ is a Kronecker product, $A^{(1)}$ (2 × 2) is orthogonal to $A^{(2)}$ (2 × 2), and $B^{(1)}$ (2 × 2) is orthogonal to $B^{(2)}$ (2 × 2).

12. The wireless device of claim 11 wherein α is greater than zero.

13. The wireless device of claim 11 wherein $A^{(1)}$ (2 × 2) equals $B^{(1)}$ (2 × 2), and $A^{(2)}$ (2 × 2) equals $B^{(2)}$ (2 × 2).

14. A method for providing a signature sequence to a mobile unit in a multicarrier direct-sequence code-division multiple-access (MS-DS/CDMA) communications system, the method comprising:

a base station generating an M × N matrix according to a matrix generation method;

the base station transmitting the M × N matrix to a mobile device; and

the mobile device utilizing the M × N matrix to serve as a signature sequence of

the mobile device;

wherein the matrix generation method comprises:

providing a first set of orthogonal 2 × 2 matrices { $A^{(1)}$ (2 × 2), $A^{(2)}$ (2 × 2)};

providing a second set of orthogonal 2 × 2 matrices { $B^{(1)}$ (2 × 2), $B^{(2)}$ (2 × 2)};

utilizing the first set of 2 × 2 matrices to generate a pair of progenitor nodes in a code tree that respectively represent matrices $A^{(1)}_{(2\times 2^n)}$ and $A^{(2)}_{(2\times 2^n)}$ by iterating the relationship:

$$A^{(1)}_{(2\times 2^{n+1})} = [A^{(1)}_{(2\times 2^n)} \quad A^{(2)}_{(2\times 2^n)}],$$
$$A^{(2)}_{(2\times 2^{n+1})} = [A^{(1)}_{(2\times 2^n)} \quad -A^{(2)}_{(2\times 2^n)}]; \text{ and}$$

utilizing the matrices $A^{(1)}_{(2\times 2^n)}$ and $A^{(2)}_{(2\times 2^n)}$ to generate a child node of one of the progenitor nodes, the child node having the M × N matrix, by iterating the relationship:

$$A^{(i-1)}_{(Q\times P)} = [B^{(1)}_{(2\times 2)} \otimes A^{(i/2)}_{(Q/2\times P/2)}],$$
$$A^{(i)}_{(Q\times P)} = [B^{(2)}_{(2\times 2)} \otimes A^{(i/2)}_{(Q/2\times P/2)}];$$

wherein ⊗ is a Kronecker product.

15. The method of claim 14 wherein children nodes of the code tree correspond to data transmission rates that are slower than those of parent nodes, thereby enabling multirate transmissions by utilizing orthogonal matrices in the code tree.

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16 ~~17~~. The method of claim 14 wherein α is greater than zero.

17 ~~18~~. The method of claim 14 wherein the first set of orthogonal 2 × 2 matrices is identical to the second set of orthogonal 2 × 2 matrices.

18 ~~19~~. The method of claim 14 wherein any two matrices at an identical layer in the code tree are orthogonal to each other, and any two matrices at different layers in the code tree are orthogonal if and only if one of the matrices is not the parent code of the other matrix.

19. ~~20~~. A method for providing a signature sequence to a mobile unit in a multicarrier direct-sequence code-division multiple-access (MS-DS/CDMA) communications system, the method comprising:

a base station generating an M × N matrix according to a matrix generation method;

the base station transmitting the M × N matrix to a mobile device; and

the mobile device utilizing the M × N matrix to serve as a signature sequence of the mobile device;

wherein the matrix generation method comprises:

providing a first set of orthogonal $2 \times 2^{\alpha}$ matrices $A^{(1)}_{(2 \times 2^{\alpha})}$ and $A^{(2)}_{(2 \times 2^{\alpha})}$;

providing a second set of orthogonal 2 × 2 matrices { $B^{(1)}$ (2 × 2), $B^{(2)}$ (2 × 2)} ; and

utilizing the matrices $A^{(1)}_{(2 \times 2^{\alpha})}$ and $A^{(2)}_{(2 \times 2^{\alpha})}$ to generate the M × N matrix by iterating the relationship:

$$A^{(i-1)}_{(Q \times P)} = [B^{(1)}_{(2 \times 2)} \otimes A^{(i/2)}_{(Q/2 \times P/2)}],$$
$$A^{(i)}_{(Q \times P)} = [B^{(2)}_{(2 \times 2)} \otimes A^{(i/2)}_{(Q/2 \times P/2)}];$$

wherein ⊗ is a Kronecker product.

20. ~~21.~~ The method of claim 20 wherein α is greater than zero.